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BORDERLANDS IN SCIENCE[1]

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THE PROBLEM

THE conventional classification of knowledge into the several organized categories, such as physics, medicine, biology, etc., is merely an artificial device largely for our convenience; a device that, unfortunately, tends to emphasize the difference between bodies of knowledge and in consequence minimizes unduly their similarities. Knowledge itself is continuous; its growth means multiplication of categories. Out of the old natural philosophy we carved chemistry, physics, botany and zoology. Within chemistry we now recognize such subdivisions as inorganic chemistry, organic chemistry, colloid chemistry and the like.

In general, these subdivisions within a given field are well sponsored by the parent science. With the growth of knowledge there comes inevitably the development of important fields lying between sciences. Some of these fields are adopted by one of the contiguous sciences; thus we have physical chemistry within the field of chemistry and astrophysics largely within the field of astronomy. Other of these subjects frequently develop into sciences which attain almost an independent status, as is illustrated by biochemistry.

There is, however, between the conventionally recognized divisions of science an extensive "no man's land," many parts of which are of great importance but which, for want of adequate sponsorship and because of certain inhibitions in connection with re-

[1] These observations are drawn largely from the discussions of this subject in meetings of committees of the National Research Council during the past year. They are presented not as a special statement from the Council, but as an individual article with the hope on the part of the author of eliciting further comment from others who may be interested in this matter.

search therein, either are slow in developing or are not cultivated at all.

In the development of these borderland fields there are frequently met difficulties which are not encountered within the limits of established fields. Frequently, as for example in the case of biophysics, progress can be made only by the cooperative efforts of two or more persons or groups of persons of very different training and view-points. The biologist is keenly conscious of the importance of the application of physical methods and principles to the study of biological phenomena; and he naturally turns to the physicist for help. The physicist, however, is very frequently engrossed with fundamental problems in his own field which are so fascinating as to take his entire attention. Furthermore, the training of the physicist in the more or less quantitative methods of the physical laboratory tends to unfit him temperamentally for the type of research, much more qualitative, of the biological laboratory.

These differences and difficulties are greatly accentuated by the fact that the two groups of scientists concerned are in general linked to different administrative departments of a given university or other institution, and it is not always easy to cut across these artificial lines of organization. Then, too, the younger scientists not infrequently feel that they are "losing caste" with their colleagues when they enter borderland fields. This attitude finds some justification in the fact that, until a given borderland field develops to the point of being generally recognized by administrative provision therefor, it is not easy for a young man entering such a field to secure a position.

In view of the importance of these several borderland fields and of the impediments, natural as well as artificial, in the way of their development, it becomes a question of some little importance to research and educational administrators to decide how this type of research can best be fostered. Granted that numerous such borderland fields exist, should efforts be made (1) to take the initiative deliberately in surveying the whole "no man's land" of science and select here and there fields which should be cultivated, and take such means as are available for such cultivation; or (2) should a policy of "watchful waiting" be adopted with view to lending encouragement to any individual or group of individuals who are working in such borderland fields; or (3) should an intermediate position be taken between these two extremes by being ready to offer assistance, so far as may be possible, to any group of workers within a given field of science who in the prosecution of a definite research program find that such program leads into the "no man's land."

Whatever the ultimate decision—if indeed any decision as to policy be possible—it is generally recognized that no worthy research program in a borderland field should be allowed "to fall between two stools" merely because it does not happen to be classified within any one of the conventional divisions of science. It should, however, be recognized that "science planning," particularly in borderland fields, should be very carefully done. Henry James, in his "Life of Charles William Eliot," records that while still a young man Eliot wrote a new text-book of chemistry and in the introduction took pride in stating that whereas previous books on chemistry had tended more and more to introduce physical elements he had eliminated those elements and made *his* book a text-book in pure chemistry!

Whatever policy is to be followed in its relation to borderland fields, it is obvious that institutions, just as an individual should do, should constantly be alive to the importance of self-study so that they may avoid the dangers of running in ruts and of allowing their procedures to become unduly crystallized.

This question of borderland fields is recognized as of special importance in university organization. It is beginning to be more generally recognized that the organization of universities into colleges and departments inhibits to a certain extent not only the development of science but the natural evolution of educational programs. To remedy such inhibition the University of Minnesota, for example, has organized a university college with a dean and faculty made up of a selected list of professors representing collectively practically all the fields of knowledge within the whole university. A student whose interests cut across the lines of university organization is registered in this university college and is put under the direction of a special committee which outlines his program of study and, in due course, awards to him the appropriate degree.

Activities of the National Research Council in Borderlands in Science

The National Research Council has already engaged extensively in the cultivation of borderland fields of science. Since the problem may be analyzed more adequately in terms of concrete projects and problems, a few illustrations will be given of the many borderland problems and fields to which the Council has already directed its attention.

Under the Division of Geology and Geography there is a Committee on the Measurement of Geological Time, which enlists the resources of geologists, physicists and chemists in its effort to measure geologic time by the rate and degree of disintegration of radioactive minerals. Geologists and mineralogists furnish the raw material for this study. Chemists determine the amount of radioactive lead present in the samples, and

from a knowledge of the rate of production of such lead determined by both physicists and chemists information as to the age of the earth is obtained. From the age of the earth one steps back into astronomy, to the cooling down of stars and to other related phenomena.

Within the same Division is the Committee on Paleobotany, set up for the purpose of encouraging research in a borderland field in which as yet there are comparatively few workers but which holds great promise for enlarging our knowledge of the life of the past.

Many years ago Professor Lindgren while chairman of the Division of Geology and Geography made a study of the outstanding unsolved problems in the field of ore deposits. That investigation was published and for several years thereafter contributions appeared on the problems which he had outlined, notably among them the suggestion that experimental work be undertaken on producing replacement phenomena under artificially controlled conditions.

The Division of Biology and Agriculture has a Committee on Radiation which has made most fundamental contributions in a borderland field. The project was initially formulated by Dr. W. C. Curtis, who realized the great advances which had been made in the study of radiation in physics and the very important biological applications thereof. Some of the findings of this Committee on Radiation will be published in a forthcoming volume which it is hoped will stimulate further research in this field.

The Division of Physical Sciences in cooperation with the Division of Geology and Geography has for some time had a large Committee on the Physics of the Earth. The work of this committee is summarized in six volumes under the following titles: "Volcanology"; "The Figure of the Earth"; "Meteorology"; "The Age of the Earth"; "Oceanography," and "Seismology."

One of the major activities of the Division of Medical Sciences has been the work of the Committee on Drug Addiction, in which possibly as much as half of the work belongs in the field of chemistry as distinct from the other half, which comes in the fields of physiology and pharmacology. The work of this Committee emphasizes the fact that one of the greatest needs in biological chemistry at present is the induction into it of thoroughly trained organic chemists who are able to analyze and to synthesize the chemical entities so intimately concerned with the physiology of the human body. Further advances in this most important field await knowledge of the actual chemical structure of these substances and the development of methods for their synthesis.

In the Division of Engineering and Industrial Research there are extensive activities in borderland fields such as are represented by work on the international steam tables, fatigue phenomena in metals and marine piling investigations. Indeed, it is perhaps not too much to say that most if not all of the activities of the Division of Engineering are to a great extent representative of borderland problems, if by such problems one means those which involve elements covered by other divisions of the Council. The very fact that engineering, as well as medicine, is an applied science means that inevitably investigations therein must draw heavily upon the pure sciences and therefore must constitute in effect a borderland field.

Other Recognized Borderlands

Geochemistry. The materials of the earth provide the starting point for the work of the chemist. The usefulness of chemistry to the geologist could perhaps be greatly increased through the perfection of rapid and relatively inexpensive methods of analyses that are roughly quantitative and applicable to small quantities of material. The well-established inorganic reactions of ordinary temperatures should be supplemented by experimentation with mixed solutions at elevated temperatures and pressures and in the presence of volatile components. Especially significant would be experiments with solutions analogous to those believed to be involved in ore deposits. The Geophysical Laboratory of Washington has carried on large amounts of chemical work of fundamental importance. The extension of these experiments to more complex systems closely imitating those occurring in nature might yield highly instructive results, even though their full explanation may not at the outset be clear. There is reason to believe that the solubility of silica is very greatly influenced by temperature and by the presence of certain salts in solution. Systematic work in this field should be undertaken.

The geologist is also keenly interested in the field of colloid chemistry. The study of ores is constantly revealing new evidence of transport and deposition of ore minerals in colloidal suspension. These are but a few of the numerous applications of chemistry to geological problems.

Bacteriology. Bacteria have played an important rôle in the formation of oil; and sulfate-reducing bacteria now living in soil waters associated with oil have notably modified their composition, converting sulfates to carbonates. The bacteriology of oil and oil-field waters should be the object of cooperative study between the biologist and the bacteriologist; that is to say, the soil bacteriologist rather than the medical bacteriologist.

Parenthetically, it seems probable that the study of classification of soils from the standpoint of fertility is a field to which the geologist could make important contributions. The problems of base exchange in soils are important to the agriculturist as well as to the

geologist and the ceramist in the origin of clays and in similar problems.

Geophysics. This subject has developed to the point of receiving recognition by the formal organizations of societies or laboratories such as the Geophysical Union and the Geophysical Laboratory of Washington. Among the major problems of geophysics are those relating to the earth's interior, its composition and the distribution of density, rigidity and temperature. The problem of equilibrium or isostatic adjustment between high- or low-line segments of the outer portions of the earth, and the problems of the mechanics of mountain-making have long demanded attention. Among other equally important problems of geophysics may be mentioned the problem of crystal growing; the physics of yielding mechanisms such as clays and sand.

Fatigue in Metals. This is a field of very great importance, involving not only various branches of chemistry and physics but engineering as well. In spite of many studies, a vast amount of work yet remains to be done, and it is probable that only a concentrated attack by the bringing together of a large number of specialists to collaborate in carrying out a well-organized plan can bring conclusive evidence to bear upon this wide field.

Photogrammetry. There is a rapidly growing literature in this field and there has recently been organized a Photogrammetric Society. The Fourth International Congress on Photogrammetry met in Paris in September, 1934. A limited number of methods have been employed in reducing aerial photographs to a plane surface. There are obviously involved in the solution of this problem both optics and mechanics as well as the distortion of the various materials employed, particularly photographic films, printing paper and the like. The American Geographical Society has for some three years been engaged in research on questions of improving existing techniques. Mathematics, physical and geometric optics, photography, psychology and chemistry all united in providing means for attacking this problem.

CONCLUSIONS

It will be agreed that borderland fields should receive some special stimulation, partly because of the inhibitions mentioned above; partly because of the fact that there are, in general, no scientific societies or journals to provide a common meeting ground for those who by chance become interested.

However, it will also be agreed that undue artificial stimulation, "by the gods on Olympus" deciding what should be done and setting other people to do it, is highly undesirable; and in the long run is likely to prove detrimental. In the fields of pure science at least, specific machinery directed toward the organization and prosecution of research has availed little. Original, enthusiastic, capable investigators are not attracted by such means. The whole history of science shows that progress rests in the main on individual initiative. It is this that must be encouraged, whether in borderlands or in the conventionally recognized subdivisions of science. In this respect promotion of research in borderland fields offers no unique problem. But how can we see to it that the individual is encouraged, and not discouraged?

Surely, no complete formula can be written. But the following suggestions are made:

(1) Steps should be taken to see that no worthy problem falls between two stools. Whenever there is presented a problem or a proposal that lies between two or more sciences, make it by special assignment the joint responsibility of competent representatives of the sciences concerned, so that the problem may be evaluated on its merits and receive suitable support.

(2) Whenever activity in a given borderland field seems to be generally developing, provision should be made under some auspices to stimulate interest by originating joint research committees representative of the fields involved.

(3) Scientific societies should be encouraged to continue to hold borderland symposia. The National Research Council would be glad to cooperate in planning these meetings.

(4) Universities should be encouraged to give special or regular courses in borderland fields; and to break down the water-tight compartments that all too frequently are found in academic circles.

(5) And in general steps should be taken to remove the inhibitions in the way of borderland fields so that they may, along with the recognized sciences, develop naturally and without regimentation.

SCIENTIFIC EVENTS

FEDERAL APPROPRIATIONS

AN Associated Press dispatch printed in *The New York Sun* reports that, according to an official accounting of approved work-relief projects, appropriations for highway and street construction work were calculated at $855,000,000. Other items in the summary of federal allotments for approved enterprises were:

Civilian Conservation Corps, $522,084,000.
School buildings, $174,243,000.
Other public buildings included in the Public Works

Administration and Works Progress Administration programs, $113,475,000.

Parks, athletic fields and similar projects under WPA, $156,610,920.

Water works, sewers, drainage and related work under WPA, $142,603,767.

"Community service" and "miscellaneous" projects under WPA, including clerical and library work and other "white collar" enterprises, $80,931,506.

Bureau of Reclamation, for power plants, dams, drainage projects, mapping, irrigation and the like, $79,650,000.

For projects under the War Department's engineering corps, including flood control, harbor dredging and preliminary work on the Atlantic Gulf canal, $144,716,169.

Resettlement Administration, $38,000,000.

Navy Department, $17,370,470—mostly for improvement of buildings and grounds at yards and docks.

Sanitation projects under WPA, $22,654,540.

Airport work under WPA, $17,399,624.

Erosion surveys and control work, under the Soil Conservation Service, $25,000,000.

National youth movement, $27,056,268.

Projects for unemployed artists, writers, musicians, actors, directors, etc., $27,315,217.

The large amount of approved highway and street projects was shown to be made up of $391,000,000 administered by the Bureau of Public Roads, $100,000,000 to pay for federal highways previously authorized under the Hayden-Cartwright act, $183,729,913 for street work under the jurisdiction of WPA, approximately $164,000,000 of secondary or farm-to-market roads to be handled by WPA and $15,989,743 of PWA grants.

The accounting covered more than $900,000,000 of approved WPA projects, $1,396,966,759 of projects under various federal departments and agencies and PWA grants amounting to approximately $330,000,000. In addition the President has approved PWA loans amounting to $182,095,581.

PWA grants for various utilities—sewers, sewage disposal plants, water systems, electric distribution systems and the like—were placed at $100,197,626.

Other approved allotments made to different government agencies include:

Bureau of Animal Industry, mainly for tick and pest control, $1,682,900.

Game protection, $266,289.

Bureau of Entomology and Plant Quarantine, $16,559,817.

Forest Service, $13,827,500. Census Bureau, for a survey of retail trade, a survey of business and preparation of an alphabetical index of the 1900 census, $9,881,948.

Construction of fish hatcheries and improvement of spawning grounds, $230,996.

Road construction in Alaska, $671,500.

Occupational survey under the United States Employment Service, $900,100.

Boats, telephone systems, repairs and improvements for the Coast Guard, $5,263,995.

Public health inventory, $3,450,000.

Survey of tax collections and tax investigations, $6,313,126.

Improvements and repairs at army posts and national cemeteries, $12,947,766.

Rural Electrification Administration, for power distribution lines, $4,818,267.

Veterans' Administration, for improvement of buildings and grounds at veterans' hospitals and other institutions, $1,234,120.

CALL FOR PAPERS FOR THE ST. LOUIS MEETING OF SECTION I (PSYCHOLOGY)

SECTION I (Psychology) will hold its sessions from Monday, December 30, to Wednesday, January 1. On Monday evening there will be a joint banquet of Sections I and Q at which the retiring vice-presidents of the two sections will give their vice-presidential addresses.

On Monday afternoon there will be a symposium on "Maturation and Learning," in which papers will be read by investigators who are doing active research in this field. This will be a joint meeting of Sections I and Q.

Since the change of the date of the meetings of the American Psychological Association from Christmas to September attendance of those interested in the meetings of Section I has steadily increased. It is hoped that a strong program of general interest to psychologists can be arranged for the St. Louis meeting and that a large number of psychologists will be able to attend. The character of the program must necessarily depend to a very large extent upon the submitted papers, and the members of Section I are urged to send in abstracts. Both theoretical and experimental papers will be acceptable.

All fellows and members of the section who wish to read papers should submit abstracts in duplicate (not more than 300 words in length) of the papers which they wish to present. The time required for the presentation of the paper up to a limit of fifteen minutes should be noted. Abstracts should be sent to the Section Secretary, John A. McGeoch, Department of Psychology, Wesleyan University, Middletown, Connecticut, not later than November 9. Members and fellows are urged to prepare their abstracts promptly. This is the only call for papers which will be issued.

JOHN A. MCGEOCH

THE SIXTH NATIONAL ORGANIC CHEMISTRY SYMPOSIUM

THE sixth National Organic Chemistry Symposium will be held in Rochester on December 30 and 31 and January 1. The arrangements are in charge of Erle M. Billings, of the Eastman Kodak Company.

The program this year is to be composed of discussions of a particular field in which the speaker is interested. Reviews summarizing the status of a particular line of investigation will be given, including the speaker's own work, with some indications of the direction which future investigations may take.

The speakers will include Drs. Homer Adkins, Marston T. Bogert, Benjamin T. Brooks, Wallace H. Carothers, James B. Conant, Louis F. Fieser, Henry Gilman, Arthur J. Hill, John R. Johnson, Morris S. Kharasch, C. Frederick Koelsch, Carl S. Marvel, Lyndon F. Small, Vincent du Vigneaud, George H. Whipple and M. L. Wolfrom.

Meetings will be held on the morning and afternoon of Monday, Tuesday and Wednesday, December 30, 1935, to January 1, 1936. Two evening meetings will be held. On Monday evening the symposium will be addressed by Dean George H. Whipple, of the University of Rochester Medical School, the Tuesday evening speaker will be President James B. Conant, of Harvard University.

Headquarters hotel will be the Hotel Seneca. Three other nearby hotels, Sagamore Hotel, Hotel Rochester and Powers Hotel, also afford adequate accommodations. Room reservations should be made directly with the hotels. In addition, arrangements have been made with the University of Rochester to permit the housing of ninety men in the men's dormitory. The charge is $1.00 per night. The Todd Union Hall Cafeteria, where meals may be obtained at very reasonable charges, is near the dormitory. It is hoped that many students of chemistry will take advantage of these arrangements, which will enable them to attend the symposium at very low cost. Dormitory reservations should be made by writing to Edwin Wiig, Department of Chemistry, University of Rochester, Rochester, N. Y. Arrangements are being made to secure reduced railroad fares to Rochester.

The complete program, with titles of the addresses and place and time of meetings, will be published later.

Dr. Arthur J. Hill is chairman of the Division of Organic Chemistry and Ralph L. Shriner is secretary.

THE NEW YORK MUSEUM OF SCIENCE AND INDUSTRY

DR. FRANK B. JEWETT, president of the Bell Telephone Laboratories and vice-president of the American Telephone and Telegraph Company, was elected on October 18 president of the New York Museum of Science and Industry by the trustees at their annual meeting.

The museum will be established in new permanent quarters in the exhibition galleries known as the Forum in the RCA Building of Rockefeller Center and a long-term program of development will be initiated.

The active support of the plan by industrial leaders was indicated by the selection of Dr. Jewett and the new members of the board. The new trustees elected at the meeting were Gerard Swope, president of the General Electric Company; Thomas J. Watson, president of the International Business Machines Company; Newcomb Carlton, chairman of Western Union Telegraph Company; Edward R. Stettinius, Jr., chairman of the finance committee of the U. S. Steel Corporation, and Nelson A. Rockefeller. Continuing trustees are representative leaders in business, banking, education and philanthropy.

The New York *Herald Tribune* writes editorially:

> Two different duties are discharged by museums of this kind. The first one historically was to serve industry itself, to make a place where samples of machines and products might be seen and expert opinion consulted about troubles met with or improvements imagined in actual industries. This duty still exists, but one perhaps still more important is that of helping the general public to understand what science and industry are about. Possession by every one of hundreds of new scientific tools, from electric lights to automobiles, has thrown new curiosities into millions of minds still fitted with intellectual furniture of an age when about the most complicated thing in common use was a wheelbarrow. There naturally is much mental indigestion, which schools have not yet been able to allay. Museum exhibits interesting enough to be attractive and simple enough to be clearly understood can do much to help.
>
> From this viewpoint the museum's enlargement scarcely could be better timed. We are to have a great fair in New York, with expected millions of visitors. In Chicago the scientific exhibits generally were considered the high point of the whole display. Dr. Jewett headed the advisory committee usually credited with this success. Under the leadership provided by his experience and energy, and with aid of the staff and facilities of the enlarged museum, there is no reason why New York's fair can not do better still. Whether the trick is turned on the grounds of the fair itself or in the new home of the museum, it should be possible to say the year after the fair is over that no visitor who came to see it went home without better understanding of what the scientific foundations of modern society really are.

RECENT DEATHS AND MEMORIALS

MAJOR GENERAL ADOLPHUS W. GREELY, meteorologist and Arctic explorer, died on October 20, at the age of ninety-one years.

MAJOR GENERAL WILLIAM LUTHER SIBERT, chairman and chief engineer of the Alabama State Docks Commission, who was from 1907 to 1914 in charge of the construction of the Atlantic end of the Panama Canal, died on October 16. He was seventy-five years old.

DR. CHARLES DUNHAM ROSE, professor emeritus of

mathematics and astronomy at Nebraska Wesleyan University, died on September 30 at the age of seventy-six years.

THE death is announced on October 20 of Frederick Arthur Halsey, formerly editor of *The American Machinist*, at the age of seventy-nine years. Mr. Halsey received the gold medal of the American Society of Mechanical Engineers in 1923 for the "Halsey Premium System."

THOMAS A. BUCKLAND, formerly New York City chemist, past president of the St. Louis College of Pharmacy, died suddenly on October 13 at the age of seventy-two years.

LEWIS A. WELLS, who was chief observer of the Blue Hill Observatory of Harvard University with which he had been connected for forty years, died on October 11 at the age of fifty-eight years.

IN memory of the late Dr. Frederick N. G. Starr, for many years professor of clinical surgery at the University of Toronto Faculty of Medicine, according to the *Journal* of the American Medical Association, Mrs. Starr has arranged for a gold medal to be awarded by the Canadian Medical Association to any member of the association who adds distinction to the profession by his attainment in science, art or literature. It will be awarded annually or when in the judgment of a committee the occasion arises for the distinction. Dr. Starr was for several years general secretary of the association and president in 1927. He died in April, 1934.

SCIENTIFIC NOTES AND NEWS

THE Chemical Industry Medal of the Society of Chemical Industry will be presented to Dr. Edward R. Weidlein, head of the Mellon Institute of Industrial Research in Pittsburgh, on November 8, at a meeting of the society held jointly with the American Chemical Society, in recognition of the valuable applications of chemical research to industry that have been carried out under his direction. Dr. Weidlein will present a paper entitled "Various Results of Being Researchful," and Dr. L. V. Redman will speak on the subject of the medalist himself. Dr. D. D. Jackson, of Columbia University, will make the presentation. The meeting will be held at 7:45 P. M. at The Chemists' Club, New York City. A dinner in honor of Dr. Weidlein will be held immediately preceding the meeting.

DR. OAKES AMES, who recently resigned as Arnold professor of botany, supervisor of the Arnold Arboretum and director of the Botanical Garden of Harvard University, has been awarded the George Robert White Medal of Honor of the Massachusetts Horticultural Society for his service to horticulture over a long period of years.

THE Architectural League has awarded the Michael Friedsam Medal for 1935 to Professor Charles Russell Richards, executive vice-president of the New York Museum of Science and Industry. This medal goes to the individual who has contributed in the greatest degree toward the development of art in industry. It was presented to Professor Richards with the following citation: "To Charles Russell Richards, distinguished educator in the fields of science and art, and notable for his constructive contributions to each; quick in his understanding of the importance of the alliance of art and industry, and foremost in the giving of practical, effective help through the spoken and written word. To the accomplishment of this end the Michael Friedsam Medal is given in worthy recognition of his service, a part of the history of the arts of decoration in this country."

A COMMITTEE of nine trustees and members of the faculty of Cornell University has been appointed "to search out available candidates for appointment as president of Cornell University and inquire into and report upon their qualifications." Last year President Farrand, who was formerly professor of anthropology at Columbia University, brought before the board the question of his retirement, and it was announced in January that he had acceded to the board's request that he continue to serve until June, 1937, when he will have reached the age of seventy years. The committee appointed by Judge Hiscock, chairman of the board of trustees, comprises five trustees and four members of the faculty, he himself having been appointed by the trustees a member *ex-officio*. The other trustee members are J. Du Pratt White, '90, chairman; Robert H. Treman, '78; Bancroft Gherardi, '93, and Jervis Langdon, '97; from the faculty, Professors Julian P. Bretz, American history; Herman Diederichs, '97, director of mechanical engineering; Carl E. Ladd, '12, dean of agriculture and home economics, and Floyd K. Richtmyer, '04, dean of the Graduate School.

THE German Röntgen Society has recently elected as honorary members Dr. Antoine Béclère of Paris; Professor Rudolf Jaksch-Wartenhorst, of Prague; Charles Thurstan Holland, of Liverpool; Professor J. M. Woodburn Morison, of London, and Dr. George E. Pfahler, of Philadelphia.

DURING the course of the Melbourne meeting of the British Medical Association, the following members received honorary degrees from the University of Melbourne: Lord Horder, Sir Henry Gauvain, Dr. J. S. Fairbairn, Sir William Willcox, Dr. Edwin Bramwell, Dr. E. Kaye Le Fleming, Sir Ewen Maclean, Dr. Robert Hutchison, Sir Lindo Ferguson and Dr. E. Wilfred Fish. The Royal Australian College of Surgery conferred honorary fellowships on H. S. Souttar and Professor Hey Groves. The Australasian federal government has announced that as the first step towards a permanent memorial of the meeting, there is to be established immediately a Federal Medical Research Council with the cooperation of the states.

DR. P. E. BROWN, head of the department of agronomy at the Iowa State College, was tendered a special dinner by the members of the department on the occasion of his fiftieth birthday on October 9, and also in recognition of the completion of twenty-five years of service in the department. Dr. W. H. Stevenson, formerly head of the department, paid tribute to Dr. Brown and to the service he has rendered to Iowa State College and to soil science.

RALPH E. FLANDERS, president of the Jones and Lamson Machine Company at Springfield, Vt., and president of the American Society of Mechanical Engineers, was the honor guest at a dinner of the Colorado section of the society on October 11. Mr. Flanders spoke on "The Engineer and Social Progress."

THE convocation of the Victoria University of Manchester gave a dinner on October 18 in honor of the new vice-chancellor, Professor J. S. B. Stopford, professor of anatomy and lately dean of the Medical School.

DR. ALFRED BIELSCHOWSKY, the German ophthalmologist who visited Dartmouth College for six months earlier in the year, has joined the faculty with the title of visiting lecturer in ophthalmology.

HAROLD S. NEWINS, associate professor of forestry at the Michigan State College, has been appointed by the Florida State Board of Control professor of forestry, to establish a department of forestry at the University of Florida.

PROFESSOR FRANKLIN FEARING, of the department of psychology of Northwestern University, has leave of absence this semester to teach at the University of California at Los Angeles; Professor J. P. Guilford, chairman of the department of psychology at the University of Nebraska, has taken his place at Northwestern University.

THE following additions have been made to the staff of the department of physiology at the Ohio State University: Assistant professors: Dr. Hans O. Haterius, of Washington Square College of New York University, and Dr. George W. Thorn, of the Massachusetts General Hospital; instructors: Dr. A. J. Derbyshire, Harvard Medical School; Dr. A. H. Hegnauer, Washington University Medical School; Dr. E. J. Robinson, Washington Square College, and Dr. S. R. Tipton, University of Rochester Medical School.

AT Temple University, Professor A. A. Schaeffer is chairman of the department of biology, not of the department of bacteriology, as was erroneously stated in a recent issue of SCIENCE.

AT the Rockefeller Institute for Medical Research, Dr. Ernest L. Spencer has been promoted from the rank of fellow to that of assistant in the division of plant pathology and Dr. Hubert S. Loring and Dr. George L. McNew have been made fellows in the division of plant pathology.

DR. EDWIN ALLEN LOCKE, clinical professor of medicine at the Harvard Medical School, has been appointed supervisor of health, physical education and the athletic program at Williams College.

CLAUD L. HORN, formerly associate horticulturist of the Virgin Islands Experiment Station, has been appointed associate horticulturist of the Puerto Rico Experiment Station of the U. S. Department of Agriculture. Mr. Horn will have charge of economic plant introductions. Dr. A. N. Watson, formerly assistant to the director of personnel and associate agricultural economist of the Bureau of Census, has been appointed biometrician and plant physiologist at the Puerto Rico Experiment Station.

HAROLD L. BABCOCK, curator of reptiles and amphibians in the Boston Society of Natural History, has been elected a member of the corporation of the Bermuda Biological Station.

LEAVE of absence for the first semester of the university year 1935–1936 has been granted to Professor Walter L. Badger, of the department of chemical engineering at the University of Michigan, so that he may complete certain investigations which he has under way at the present time.

DR. OSCAR RIDDLE, investigator at the Carnegie Station for Experimental Evolution, Cold Spring Harbor, Long Island, has returned from an extended tour of European laboratories after attending the International Physiological Congress in Leningrad as delegate of the Carnegie Institution of Washington.

DR. ROLLINS A. EMERSON, professor of plant breeding and formerly dean of the Graduate School at Cornell University, has completed, with his associate,

J. H. Kempton, of the U. S. Department of Agriculture, a preliminary survey of the system of maize culture practised by the Maya Indians of the northern part of the Yucatan Peninsula.

DR. ROSS A. GORTNER, professor of agricultural biochemistry and chief of the division of biochemistry at the University of Minnesota, George Fisher Baker nonresident lecturer in chemistry at Cornell University for the first term this year, gave a public lecture on October 16 on "Scientific Genealogy."

DR. THOMAS M. RIVERS, of the Rockefeller Institute for Medical Research, New York, will deliver the annual Lilly Heard Anderson lecture in pediatrics at the Academy of Medicine in Atlanta on November 14. His subject will be "Virus Diseases of the Central Nervous System."

DR. WILDER D. BANCROFT, professor of physical chemistry at Cornell University, whose grandfather, George Bancroft, founded the United States Naval Academy as Secretary of the Navy under President Polk, was a principal speaker at exercises in Annapolis, Md., commemorating on October 10 the ninetieth anniversary of the academy. Later, at Washington, D. C., Dr. Bancroft helped to dedicate a tablet to his grandfather, placed on the house where the former secretary lived.

DR. FRED CONRAD KOCH, professor of physiological chemistry and chairman of the department of physiological chemistry and pharmacology at the University of Chicago, delivered the seventh annual William T. Belfield Lecture before the Chicago Urological Society on October 24. The subject of the lecture was "The Biochemistry and Physiological Significance of the Male Sex Hormones."

DR. EDWARD KASNER, professor of mathematics at Columbia University, addressed on October 5 the Galois Institute of Mathematics on "Transformations and Groups in Geometry."

THE North Central Branch of the Society of American Bacteriologists held its second semi-annual meeting at the University of Wisconsin on October 11. Contributed papers on various phases of bacteriology were presented at the forenoon and afternoon programs. At the evening dinner meeting at which there were ninety in attendance, Dr. Paul F. Clark, of the University of Wisconsin, spoke on the "Sources and Modes of Infection in Poliomyelitis." Officers for the present year were elected as follows: Dr. R. E. Buchanan, Iowa State College, *president;* Dr. A. T. Henrici, University of Minnesota, *vice-president;* Dr. R. H. Walker, Iowa State College, *secretary-treasurer,* and Dr. E. B. Fred, University of Wisconsin, representative on the council of the national society.

DR. HOWARD W. HAGGARD, associate professor of applied physiology at Yale University, will give the second public lecture in the new series sponsored by the New York Academy of Medicine on November 14, on "Medicine in the Days of the Great Monarch." Other lectures will be given by Dr. Alexis Carrel, of the Rockefeller Institute for Medical Research, on "The Mystery of Death," December 12; Dr. Harlow Brooks, "Medicine of the American Indian," January 9; Dr. Benjamin P. Watson, "How We Learned About the Human Body," February 13; Dr. Foster Kennedy, "The Organic Background of Mind," March 12; Dr. Elmer V. McCollum, the Johns Hopkins University, "The Story of Vitamins," April 9; Dr. George Draper, "Man—The Common Denominator of Disease," May 14. The first lecture in this series was given by Dr. Walter B. Cannon, on October 3, on "The Wisdom of the Body."

THE Pennsylvania Conference of College Physics Teachers was held on October 11 and 12 at State College, Pennsylvania. The principal speaker was Dr. Paul D. Foote, executive vice-president of the Gulf Research and Development Corporation, Pittsburgh, whose topic was "Research in the Petroleum Industry." There were sessions for both students and teachers. Dr. Wheeler P. Davey, of State College, chairman of the conference, presided. The spring meeting of the conference will be held at Wilson College, Chambersburg, Pa.

THE two hundred and first regular meeting of the American Physical Society will be held in Baltimore, Maryland, on Friday and Saturday, November 29 and 30, at the Johns Hopkins University. Other meetings for the current season are as follows: 202. Berkeley, California. December 20–21, 1935; 203. Annual meeting. St. Louis, Missouri. December 31, 1935-January 2, 1936.

THE twenty-fourth annual meeting of the American Association of Variable Star Observers was held at the Harvard College Observatory on October 18. Charles W. Elmer, of New York, vice-president of the association, and Professor Harlow Shapley, Leon Campbell and Dr. Annie Jump Cannon, of the Harvard Observatory, were among the speakers.

AN Intersectional Meeting of the American Chemical Society will be held in Schenectady and Troy on October 25 and 26. The activities will begin with registration at Rice Hall, General Electric Company, at Schenectady at 9:30 A. M., Friday, followed by inspection trips of various parts of the General Electric Works and a series of short talks and demonstrations by members of the research staff of the General Electric Company. Following a greeting by Dr. Edward

Ellery, professor of chemistry and chairman of the faculty of Union College at the chemical laboratory, papers will be presented. The visitors will then go to Troy and will inspect the new aeronautical, chemical and metallurgical engineering laboratory of Rensselaer Polytechnic Institute. An informal dinner will be held at 7:00 P. M. at which the president of the institute, Dr. William O. Hotchkiss, will greet the visitors. At 8:30 P. M. Dr. C. E. K. Mees, of the research department of the Eastman Kodak Company, will give an illustrated lecture on "Color Photography and the Kodachrome Process." Saturday morning will be given over to the presentation of papers at the Walker Chemical Laboratory.

IN order to have as its guest and principal speaker Dr. Robert A. Millikan, of the California Institute of Technology, the annual meeting of the U. S. Institute for Textile Research will be postponed from November 7 to November 14, but will be held as originally planned at the Waldorf-Astoria, New York, N. Y. To celebrate the end of its fifth year, and to honor Dr. Millikan, the institute will give a dinner that evening at which President Francis P. Garvan, who is also president of the Chemical Foundation, will act as toastmaster. Another feature of the dinner will be reports of several applications of scientific textile research in the mills by technicians responsible for them. Dr. J. R. Katz, director of the institute's warp sizing research, now in progress at the Massachusetts Institute of Technology, will also speak. The regular annual meeting and meeting of the board of directors will be held in the morning. In the afternoon the Research Council will hold an open conference on the subject of creping of regenerated rayon and acetate fabrics, to which all who are interested are invited.

DISCUSSION

THE SOLUTE AS LIQUID

ONE of van't Hoff's great achievements was the proof that in dilute solutions a dissolved substance behaves in some respects like an ideal gas. A corollary, not drawn by van't Hoff, was to consider the solute as in all respects like a gas. Nernst[1] stated that a third substance, added in small amounts, has no more effect on the solubility than a gas will have on the partial pressure of a solid. This is not true experimentally, because any addition of alcohol to a saturated solution of sugar or sodium chloride will cause a decrease in solubility.[2] There is no need of speaking of a change in thermodynamic environment.

If we start with ether and methyl alcohol, the alcohol is called a gas and the ether a liquid at all concentrations if one has a rubber diaphragm, while the ether will be called a gas and the alcohol a liquid at all concentrations if one uses an animal bladder membrane. On the other hand, one of the criteria of two ideal liquids, benzene and toluene at 35°, is that the two shall mix without volume expansion or contraction. So far as volume relations are concerned, neither liquid behaves as a gas at any concentration.

This has been recognized by Lumsden,[3] who stated that a binary, non-aqueous solution is a mixture of two liquids. He excluded aqueous solutions because of difficulties in connection with ionization, hydration, etc. While these present problems experimentally, they do not affect the general principles. Putting Lumsden's concept in a broader form, all liquid solutions are mixtures of liquids, regardless whether any or all of the pure components are solids, liquids, vapors or gases at the temperature of the experiment. As such, all the components will show some of the properties of liquids.

If either component of a binary solution may act in some respects as a liquid and in other respects as a gas, we must clear up the apparent discrepancy. That is merely a question of wording. Instead of saying that at low concentrations the solute behaves more or less like an ideal gas so far as osmotic pressure relations are concerned, we say that at low concentrations a solute (present as liquid) or a suspended particle (present as solid, liquid or gas) behaves more or less like an ideal gas so far as osmotic pressure is concerned. This includes both the van't Hoff generalization and also the Einstein[4] generalization that suspended particles behave like an ideal gas when the sol is dilute.

Perrin[5] speaks of gamboge granules large enough to be visible in sunlight under a strong lens as behaving like an ideal gas with a molecular weight of two hundred thousand tons. Nobody supposes that these gamboge particles are gases or that the crystals of gold in a red gold sol are not solid. When we call a solute a gas, it is a purely metaphysical gas.

Some interesting consequences follow. A fused salt is a liquid. If the fused salt is considered to be completely dissociated, the ions must be liquids at the temperature in question. If the fused salt is not completely dissociated, the ions must either be liquids or

[1] Nernst, "Theoretische Chemie," 386, 1893; Nernst-Codd, "Theoretical Chemistry," 564, 1923.
[2] Lash Miller, *Jour. Phys. Chem.*, 1: 633, 1897.
[3] Lumsden, *Jour. Chem. Soc.*, 91: 24, 1907.
[4] Einstein, *Ann. Physik*, (4) 17: 549, 1905; 19: 280, 371, 1906.
[5] Perrin, "Brownian Movement and Molecular Reality," 46, 1910.

they must be gases dissolved in the liquid, undissociated salt. Owing to the practically complete absence of salt ions in the vapor phase under ordinary conditions, it is improbable that the ions of a fused salt are to be considered as dissolved gases. We conclude, therefore, that a fused salt consists of liquid ions and an unknown amount of liquid undissociated salt. As liquids, the two ions and the undissociated salt singly must have solvent or precipitating action, and this action must be selective. With sodium nitrate, potassium nitrate and lithium nitrate, each salt lowers the freezing point of either of the others.

In aqueous solutions of two salts with a common ion, we have, theoretically at least, a decrease of solubility, on account of the precipitating action of the common ion and an increase in the solubility due to the mutual solvent action of the two salts. If one of the salts is sparingly soluble, the solvent action of the other will be negligible in low concentrations and the precipitating effect of the common ion will be practically the whole thing.

There is no evidence of a complex salt between sodium and potassium nitrate; but potassium nitrate is more soluble in a sodium nitrate solution than in pure water. This is probably due to solvent action by liquid sodium nitrate and its liquid ions, anhydrous or hydrated as the case may be. One can predict that, at high enough temperatures, all the isotherms for water and two salts with a common ion, forming no other solid phases than these two pure salts, will be concave to the water corner of the triangular diagram, instead of being convex, as most of them now are.

If a sparingly soluble salt behaves like a dissociating gas, the concentration of the undissociated portion in a saturated solution should be constant, irrespective of the addition of another salt with a common ion. Arrhenius[6] showed that addition of sodium monochloracetate to a saturated solution of silver monochloracetate forced the total solubility of the silver salt below the calculated concentration of the undissociated silver salt in water. Similar results were obtained with silver propionate and butyrate and the corresponding sodium salts. We do not yet know why this should be; but we know now that the belief that the concentration of the undissociated portion of the silver salt must remain constant was based on the false assumption that the solute must behave in all respects like a gas.

When solid benzene dissolves in liquid toluene at −20°, we do not postulate solvation. We merely say that benzene is soluble in toluene—as it is. When sodium nitrate dissolves in nearly pure nitric acid, sodium acetate in pure acetic acid or lead sulfate in pure sulfuric acid, we do not postulate solvation, though it may occur. We say that these substances are soluble in these liquids, just as we say that sodium chloride or sugar is soluble in water. If we start with a saturated solution of lead sulfate in water and add sulfuric acid continuously, there is at first a decrease in solubility owing to the presence of a common ion, and then an increase in solubility.[7] One should say that lead sulfate is soluble in sulfuric acid and is precipitated by water. There is a minimum solubility for lead chloride and hydrochloric acid, calcium sulfate and sulfuric acid, fluorides and hydrofluoric acid, and doubtless in many other cases.

Schukow[8] showed that potassium chloride and sodium chloride increase the solubility of sugar in water, but nobody knows whether this means that sodium and potassium chlorides are soluble in melted sugar.

The general results of this paper are:

(1) All liquid solutions are mixtures of liquids, regardless whether any or all of the pure components are solids, liquids, vapors or gases at the temperature of the experiment.

(2) The ions in a fused salt or in a solution are present as liquids and may exert a precipitating or solvent action.

(3) In low concentration a dissolved liquid or a suspended particle will behave in some respects like a gas. This postulate reconciles the conclusion of van't Hoff on true solutions and of Einstein on sols with the fact that true solutions are mixtures of liquids, showing in some cases the properties of liquids, and with the fact that the dispersed phase in a sol is rarely a gas.

(4) While it is customary and profitable in physical chemistry to treat the solute thermodynamically as a gas under certain circumstances, it is actually a liquid and is a gas only in a metaphysical sense. It is then not preposterous to say that the osmotic pressure may be that of a gas in a volume into which the liquid solute could not possibly be compressed.

(5) When dealing with the effect of one salt on the solubility of another salt, it is not safe to ignore the direct or indirect solvent or precipitating effect of the third ion or the undissociated salt on the solubility of the second salt.

Wilder D. Bancroft
Cornell University

[6] Arrhenius, *Z. physik. Chem.*, 31: 225, 1899.

[7] Ditz and Kanhäuser, *Z. anorg. allgem. Chem.*, 98: 128, 1916.

[8] Schukow, *Z. Vereins deutsch. Zucker-Industrie*, 50: 291, 1900.

ON THE FORMATION OF LAKE BALLS

Under this heading in Science for August 30, A. G. Huntsman describes certain balls obtained by Dr. H.

S. Everett in 1919 from Little Kedron Lake, New Brunswick, and concludes that they were formed, not by building up around a central core, but by the breaking-up of a mat of the material and subsequent rounding-off by wave action. He adds: "As this method of the formation of lake balls seems not to have been hitherto recognized, it seems worth while to present the case for it." I do not question the accuracy of this last statement so far as the scientific literature is concerned, but Henry D. Thoreau appears to have reached the same conclusion in 1854. In the chapter of "Walden" entitled "The Ponds," writing of Flint's, or Sandy Pond in Lincoln, Massachusetts, he says:

> There also I have found, in considerable quantities, curious balls, composed apparently of fine grass or roots, of pipewort perhaps, from half an inch to four inches in diameter, and perfectly spherical. These wash back and forth in shallow water on a sandy bottom, and are sometimes cast on the shore. They are either solid grass or have a little sand in the middle. At first you would say that they were formed by the action of the waves like a pebble; yet the smallest are made of equally coarse materials, half an inch long, and they are produced only at one season of the year. Moreover, the waves, I suspect, do not so much construct as wear down a material which has already acquired consistency. They preserve their form when dry for an indefinite period.

The first entry in Thoreau's published journal relating to this subject is under date of October 3, 1852: "Collected a parcel of grass (?) balls, some washed up high and dry—part of the shore-line consists of the same material—from a half-inch to four inches in diameter." The place was Flint's Pond, and the finding of grass balls at the same pond is recorded in the journal on August 19, 1854 ("washed up apparently a month ago"), July 22, 1855 ("within a few days"), and July 24, 1856. The "season" referred to in "Walden," was therefore, evidently summer.

Another view of the formation of grass balls was taken by that close observer of the phenomena of the sea beach of Ipswich, Massachusetts, Dr. Charles W. Townsend, who says in his "Sand Dunes and Salt Marshes" (1913):

> As one walks along the edge of the dunes near the beach in summer or winter, his attention may be attracted by a number of balls which appear to be made up of broken pieces of straw or grass. Some of these are not larger than a tennis-ball, others the size of a cocoanut; some are perfectly spherical and firmly matted; others are loosely formed and often elongated in shape. . . . It is evident from a careful study of these balls *and by actually watching their formation* [the italics are the present writer's] that they are gradually built up in shallow water near the shore by the rolling action of the waves on particles of broken thatch [spartina], sticks, seaweed and grass which have collected in hollows and ripple-marks. A nucleus once started, more and more material is added as the ball rolls about.

I have examined Dr. Townsend's manuscript notes, presented by his son to the Boston Society of Natural History, with the hope of finding exactly what he meant by "actually watching their formation," but was disappointed, for these carefully classified note-sheets seem to contain nothing whatever on the subject of grass balls.

My excuse for making these two quotations from what may be called literary literature is that they are both the considered statements of careful observers, and that such records, published outside of strictly scientific journals and books, are too easily overlooked by specialists. My own experience with grass balls has been limited, but my (ornithological) journal for October 16, 1904, records the finding of two at Ipswich and the facts that they consisted of grass fragments crisscrossed every way "like a handful of jackstraws" and that they remained intact after being brought home in my pocket and subjected to rough usage.

FRANCIS H. ALLEN

WEST ROXBURY, MASS.

THE PHENOMENON OF MASKING

THOMPSON[1] has recently criticized the application of the term "masking" to the observed diminution of one sound in the presence of a second sound on the grounds that auditory "masking" is a peripheral phenomenon. The term "masking," he insists, has already been appropriated to describe the case in which the phenomenon is of central origin. However, as early as 1924 Wegel and Lane[2] made a thorough study of what they called auditory masking in an effort to obtain quantitative information regarding the phenomena reported by Mayer in 1876. Thus it happens that the term "masking" has sunk its roots too deeply into the literature on audition to permit convenient banishment. Furthermore, Wegel and Lane more than a decade ago pointed out that auditory masking must be both central and peripheral.

Independent of the problem of the priority of usage, there is the more important problem of convenience and utility. The living organism is so constituted that in any sensory modality the presence of a sufficiently strong stimulus obliterates the response to a simultaneous weaker stimulus. This universal phenomenon needs a name—preferably a word whose meaning in the English language is well established and readily understood. The word "masking" is obviously well

[1] I. M. Thompson, SCIENCE, 82: 221, 1935.
[2] R. L. Wegel and C. E. Lane, *Phys. Rev.*, 23: 266, 1924.

suited as a name for this important fact, whose defining properties are clear and accessible.

Finally, three considerations counsel against the attempt to limit the meaning of masking to a central phenomenon: (1) The term is too widely current to allow such arbitrary restriction to gain acceptance. (2) In most cases of observed masking in the various sense departments we are still ignorant of the physiological mechanisms underlying the phenomenon. (3) In some cases (as in audition) masking has both peripheral[3] and central causes, and it is quite possible that occurrences at intervening synaptic junctions provide additional causal factors.

S. S. STEVENS

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A COMPREHENSIVE MORPHOLOGY OF SPHENODON

A SMALL group of New Zealand morphologists, headed by Dr. W. P. Gowland, of the anatomy department of the University of Otago, Dunedin, has undertaken the laudable project of completing, as far as possible, our knowledge of the morphology of Sphenodon.

Interest in this important reptile, now facing rapid extinction, has been so widespread that no one individual is in convenient position to collate the scattered literature and decide, single-handed, what needs most to be done in further research upon this form.

Dr. Gowland will therefore welcome suggestions from zoologists who are better aware of lacunae in their special anatomical and histological fields which investigations on this "living fossil" may fill. It is expected that the necessary specimens will be obtainable through the New Zealand government, which for some time has exercised a rigid protection of the species in an attempt, now apparently vain, to preserve it.

GORDON L. WALLS

STATE UNIVERSITY OF IOWA

SCIENTIFIC BOOKS

BIOCHEMISTRY

A Text-Book of Biochemistry. Edited by BENJAMIN HARROW and CARL P. SHERWIN. Published by W. B. Saunders Company, Philadelphia, 1935; 797 pages.

ADVANCED students of biochemistry will welcome this volume. It marks a new departure from the conventional form of text-book in this branch of science in that thirty authors, English and American, have collaborated in its production. Monographic in style, each chapter is a comprehensive review by an investigator actively contributing to the field which he is discussing. The presentation of biochemistry from so many different angles and the emphasis on recent developments is most stimulating to the research worker and graduate student. It is a type of text which may prove less adaptable to the needs of the unoriented beginner, since it does not show the unified development of the science as a whole nor the historical background of the earlier books. The range of subjects is sufficiently broad to permit a selection of suitable material for the usual medical school course which follows no single text.

One is impressed throughout the book with the broad growth and rapid assimilation in the past few years of chemical knowledge in the various biological fields. Three new subjects are introduced in the form of chapters on the living cell, on the biochemistry of bacteria, yeasts and molds, and on immunochemistry. About one third of the volume is devoted to a full description of the organic and physical chemistry of the carbohydrates, fats and nitrogenous compounds, and the balance to their functions and metabolism in the body. The importance of the recently established structural formulae and of new synthetic compounds is well stressed in the chapters on the sterols and related compounds, the vitamins, the animal pigments and the hormones. Although some of the sections seem to be too short to allow an adequate discussion of the material, notably those on nutrition, digestion, mineral metabolism, bone and functions of water, some of the longer chapters, such as the vitamins and carbohydrate metabolism, deserve mention for their clarity and completeness. In most cases the argument is well fortified by citations of original publications, and the bibliography of some 1,500 articles assures its place as a reference book.

WILLIAM H. CHAMBERS

CORNELL UNIVERSITY MEDICAL COLLEGE

NEW YORK CITY

SEED SCIENCE

Seed Science for Japanese Agriculturists, Horticulturists, and Foresters. By MANTARŌ KONDŌ, director of the Ōhara Institute, Kurashiki, Japan. Yōkendō and Co., Tokyo. Vol. I, 1933, 469 pp., 43 illustrations. Yen 4.80. Vol. II, 1934, 835 pp., 358 illustrations. Yen 9.00.

IT may seem presumptuous for one who is ignorant of the significance of a single ideograph to attempt a review of a work in the Japanese language, but the

[3] H. Davis, *Jour. Acoust. Soc. Amer.*, 6: 207, 1935.

case is exceptional. Doubtless Dr. Kondō would have supplied a synopsis in English, with which language he is familiar, but this seemed unnecessary, partly because his long series of papers in German and English, on which his book is largely based, are at the reviewer's elbow and partly because the faithfully executed illustrations in the work, especially those showing the histological structure of seeds, are eloquent to a specialist in this field without referring to the text. Although the shelf-backs, title pages and main text of the two volumes are entirely in Japanese characters, the names of authors and the Latin names of species throughout the work are in Latin type, as are also the English, German and French references in the bibliography of 1,123 titles and the technical terms in the glossary and index.

Kondō, who studied with Wittmack at the University of Berlin, wrote his earlier papers and some recent ones in German, but during the past few years he has published in English a noteworthy series on methods of storing rice of bumper harvests so as to avert famine during lean years.

Nobbe's and Harz' standard books on seed science —"spermology," the lexicon equivalent for Samenkunde, sounds strange and is here avoided—have long awaited a reviser. Neither has been translated into English and no comprehensive work in our language has yet appeared. Kondō's work stands supreme, and all that is needed to make it available to the greatest numbers is an English translation.

A few years since, the writer of this review was honored by a short visit from Dr. Kondō, who was making a world tour via Siberia, Russia and Germany. While in Berlin, with oriental respect for the aged, his evenings were spent devotedly with his infirm teacher, Wittmack. One is reminded of the great Japanese bacteriologist who annually performed rites for the repose of the soul of his teacher, the immortal Koch, at the Shintoist shrine in his institute.

ANDREW L. WINTON

FOODS IN JAPAN

The Chemical Analysis of Food in Japan. By T. SAIKI, T. HIGUCHI, M. KONDŌ and K. MATSUZAWA. Third enlarged edition, 353 pp. Nankodo and Company, Ltd., Tokyo. 1934.

ON a recent visit to Japan, I had the privilege of renewing my acquaintance with Dr. Tadasu Saiki, an old student of Lafayette B. Mendel's at Yale, who is the director of the Imperial Government Institute for Research in Nutrition in Tokyo. There I learned among other interesting things that this institute has issued recently a third enlarged edition of a monograph which is almost unknown in America, but which should be of very great interest to food chemists and students of nutrition. This book, "The Chemical Analysis of Food in Japan," gives the chemical composition of a very large number of foods used in Japan (edible part, water, total nitrogen, protein, fat, carbohydrate, fiber, ash, water-soluble ash, water-insoluble ash, alkali value, alkalinity due to soda and potash, alkalinity due to lime and magnesia, P_2O_5, CaO, Fe_2O_3, NaCl, number of calories in 100 grams). It also contains tables giving the weight of food corresponding to 100 calories and the amount of water, protein, fat, carbohydrate, fiber and ash in 100 calories. It also gives tables of the calorific ratio of the constituents contained in 100 calories of food. The legends at the beginning of all tabulations are in English as well as in Japanese. The index gives the Japanese names in our alphabet as well as the Chinese characters or *kana*. There are also key tables giving the Japanese name in *kana* and characters as well as in our alphabet; also the corresponding English word, if there is an equivalent, and in the case of animal and vegetable products the Latin scientific name. All figures are of course in Arabic numerals. It is therefore a perfectly simple matter to use this book without any knowledge of Japanese whatever.

CARL L. ALSBERG

FOOD RESEARCH INSTITUTE
STANFORD UNIVERSITY

SOCIETIES AND MEETINGS

THE NINTH ANNUAL FIELD CONFERENCE OF THE KANSAS GEOLOGICAL SOCIETY

MEMBERS and guests of the Kansas Geological Society participated recently in the ninth annual field conference, a geological excursion which extended from Iowa City, Iowa, to Duluth, Minnesota, and encompassed about 1,542 miles. The society, organized for purposes of geological research with special application to petroleum geology, inaugurated the field conferences in 1927. Its membership had expressed the desire to study in outcrop the several formations which, in daily routine, were customarily examined in well cuttings. In carrying out this purpose the members have visited and revisited the general peripheral localities of the western interior petroliferous province and the principal areas of local uplift, including the Ozarks, Arbuckle Mountains and the Black Hills. In completing the ninth annual field conference, the society now has added a few links to a chain of field investigation which extends from the general vicinity of Amarillo, Texas, along the foothills of the

Colorado Rockies, through the Black Hills to the Pre-Cambrian regions of southwestern and northeastern Minnesota, and through Wisconsin and northwest Illinois to the Ozarks of southeastern Missouri. The total distance covered in the nine conferences amounts to 9,362 miles, the time spent by the parties in the field has been 61 days, and joint investigations and discussions have been made at 433 "stops."

The ninth field conference, lasting from August 25 to September 1, 1935, was arranged by two committee groups, one representing the society, with its headquarters in Wichita, Kansas, and the other composed of state geologists and their assistants in the several states included in the itinerary of the conference. The Wichita committee was in charge of Anthony Folger, with Harvel E. White as business manager and E. A. Wyman as advance agent. The local committee was directed by Dean G. F. Kay, State University of Iowa, who had charge also of the first field conference of the society in 1927. To A. C. Trowbridge, state geologist of Iowa, was given the active leadership of the conference, a task which has required two years of planning in order to fashion the log of the route followed, the selection of exposures studied and the editing of the guidebook, which became in effect a geological monograph.

Assembled with Trowbridge as associate directors of the conference were the state geologists of Illinois, Minnesota and Wisconsin, M. M. Leighton, W. H. Emmons and E. F. Bean, respectively, and A. C. Tester, assistant state geologist of Iowa. The discussions in the field were given by men who have specialized in the stratigraphy and general geology of the regions visited. In Iowa, G. Marshall Kay, A. C. Tester and M. A. Stainbrook served as lecturers. J. M. Weller presented the stratigraphic and general geology of northwestern Illinois. F. C. Thwaites, Andrew Leith and G. O. Raasch discussed the physiography, structural features and stratigraphy of Wisconsin, and G. M. Schwartz, G. A. Thiel and L. H. Powell lectured for the group while it was in Minnesota. On several occasions A. C. Trowbridge made introductory statements concerning the general bearing of the geological problems presented in the type sections and type localities visited. Josiah Bridge, of the U. S. Geological Survey, presented instances of correlations of units in the northern and southern Mississippi Valley regions. To supplement the discussions made at the stops, the guidebook includes detailed sections and extended reviews of the controversial aspects of certain of the interpretations offered.

The daily study in the field during the conference was further agumented by evening programs. In the first of these programs the group listened with profit to the discussion of the Pleistocene features of the entire area of the conference excursion presented by Dean Kay on August 25. Further comments on the Pleistocene geology were offered at that meeting by Drs. Leighton, Thwaites and Tester. At another evening meeting, in response to the conference invitation, Dr. E. O. Ulrich gave a résumé of his foundational studies in the stratigraphy of the Upper Mississippi Valley. At that meeting E. F. Bean and G. O. Raasch paid fitting tribute to the labors of Ulrich in Wisconsin. On August 29, A. Irving Levorsen, president of the American Association of Petroleum Geologists, submitted "The Oil Migration Problem" and a spirited and interesting discussion followed his address. In the last of the evening meetings, on August 30, G. M. Schwartz, of the University of Minnesota Geology Department, discussed the "Geology of the Minneapolis-St. Paul Metropolitan Area." For this area of 1,000 square miles the studies of Schwartz and his associates were presented in the areal geology map submitted for inspection as well as in the address of the evening. The only non-geological topic of the evening meetings was that of Dr. F. C. Mann, of the Mayo Clinic, who lectured on the "Methods of Medical Progress" now employed by medical science. The interest of geologists in their physical well-being was manifest in the number of questions asked of Dr. Mann at the conclusion of his address.

The chief objectives kept before the conference were the problems of stratigraphy, structure and correlation, but considerable interest was maintained in the erosional history of the region. The stratigraphic sequence from the Pre-Cambrian to the Devonian was examined in some detail and emphasis was given to the separation and definition of several formations of Cambrian age in Wisconsin and Minnesota. Some recent and most interesting discoveries and conclusions regarding the stratigraphy and glacial history of the region are incorporated in the guidebook and will be announced again in forthcoming publications.

The Kansas Geological Society has always extended a hearty invitation to others than its members to join in the field conferences. In consequence a number of students and teachers of the science have regarded the conferences as a postgraduate course and have availed themselves freely of the excursions, the meetings and the personal contacts that characterize the enterprise. Among the registrants for the Upper Mississippi Valley conference were men and women from Alabama, Colorado, District of Columbia, Georgia, Kentucky, Ohio, New York, Pennsylvania, Texas and one from Australia. This is in addition to the persons present from the states involved in and connected with the conference field. Apart from petroleum geologists, the registered group included four state geologists,

three assistant state geologists and at least five other members of state geological surveys: three members of the U. S. Geological Survey, eighteen college and university professors, three members of museum staffs, two engineers, one mining engineer, one member of a state highway commission and an uncounted number of laboratory research investigators and graduate students. The attendance, according to unofficial accounts, was approximately one hundred for a part of the trip and approximately one half that number registered for one of the optional day trips, following the formal adjournment of the conference. The post-conference trips offered either the country of the iron ranges of northeastern Minnesota or the Keweenawan sediments and lava beds of northern Wisconsin, according to the option of the participant.

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SPECIAL ARTICLES

FRACTIONATION STUDIES ON PRO-VITAMIN D

PREVIOUS work from these laboratories[1,2,3] demonstrated: (1) that cholesterol which had been purified by methods which destroyed ergosterol still retained some residual provitamin-D activity; (2) that cholesterol purified by different methods varied somewhat in the amount of residual provitamin D; (3) that the provitamin D of cholesterol purified through the dibromide could be enhanced 100 times by heating this cholesterol at 185°–200° for one hour in the presence of traces of oxygen; and (4) that boiling in an alcoholic solution of sodium hydroxide also enhances the provitamin-D factor, but to a lesser degree. Table I gives a summary of these findings.

TABLE I
EFFECT OF VARIOUS PURIFICATION METHODS ON PROVITAMIN D OF CHOLESTEROL

Sample	Treatment	Daily dose to produce 2+ cure in 10 days	Absorption spectra
Cholesterol W	Commercial product	0.1 mg	Ergosterol bands and general absorption
Cholesterol A	Cholesterol W treated with boiling 10 per cent. NaOH in alcohol, dissolved in ether, washed with water, ether evaporated, residue recrystallized 5X from acetone	2.5 mg	No absorption
Fraction II	Cholesterol separating in emulsion layer between ether solution and water washing	0.1 mg	General absorption
Cholesterol A sublimate	Cholesterol A heated 200°–210° three hours at 7–10 mm pressure	0.1 mg	General absorption
Cholesterol A residue	Residue left in tube after heating	0.1 mg	General absorption
Purified cholesterol	(1) Through the dibromide	7–10 mg	No absorption
	(2) Boiling 3X with $KMnO_4$ in alcohol	3 mg	No absorption
	(3) Acetylation and acid hydrolysis	4 mg	No absorption
	(4) Acetylation and alkaline hydrolysis	1.5 mg	No absorption
Alkaline-treated cholesterol	Cholesterol treated 3X with $KMnO_4$ and boiled 5 hours in 5 per cent. NaOH in alcohol	0.75 mg	Slight general absorption

These findings led to the conclusion that provitamin-D activity is not limited to ergosterol, but that cholesterol itself or a modification of it produced by heat or by alkali or both of these forms also have provitamin-D potency.

Waddell's[4] findings that crude cholesterol and cholesterol purified by boiling in an alcoholic solution of potassium hydroxide, when irradiated, was more effective in preventing leg weakness in chicks than an equivalent number of rat units of irradiated ergosterol led us to test our heated cholesterol in the same manner. Ten groups of white Leghorn chicks were fed the basal ration described by Lachat, Halvorson and Palmer.[5] The following additions were made to the diets of nine of the groups: 0.25 per cent. cod liver oil, 0.25 per cent. 10,000X viosterol diluted 1,000 times, 0.01 per cent., 0.03 per cent., and 0.06 irradiated, heated, purified cholesterol, 0.01 per cent. irradiated filtrate residue from heated cholesterol, 0.1 per cent. irradiated purified cholesterol, and 0.01 per cent. and 0.03 per cent. commercial cholesterol. Table II gives the results obtained.

[1] Fred C. Koch, Elizabeth M. Koch and Ida Kraus Ragins, *Jour. Biol. Chem.*, 85: 141–158, 1929.

[2] Elizabeth M. Koch, Fred C. Koch and Harvey B. Lemon, *Jour. Biol. Chem.*, 85: 159–167, 1929.

[3] Milicent L. Hathaway and F. C. Koch, *Jour. Biol. Chem.*, 108: 773–782, 1935.

[4] J. Waddell, *Jour. Biol. Chem.*, 105: 711–729, 1934.

[5] L. L. Lachat, H. A. Halvorson and L. S. Palmer, *Jour. Assoc. Official Agr. Chem.*, 15: 660–675, 1932.

TABLE II
COMPARATIVE ANTIRACHITIC POTENCY OF COD LIVER OIL, VIOSTEROL AND IRRADIATED, HEATED CHOLESTEROL IN RATS AND CHICKS

Supplement to basal ration	Rat units per 100 gm diet	Chick assay				Remarks
		Av. wt. at 30 days	Av. gain in wt.	Line test	Bone ash per cent.	
		gm	gm			
None	0	116	66	Rickets	29.9	All symptoms of leg weakness; marked tendency to squat at 2½ weeks.
0.25 per cent. cod liver oil	10	196	146	Good calcification	44.7	Chicks strong; active.
0.25 per cent. viosterol 1–10,000X diluted 1,000 times	100	108	63	Rickets	33.3	All symptoms of leg weakness; marked tendency to squat at 2½ weeks.
0.01 per cent. irradiated, heated, purified cholesterol	10	204	159	Good calcification	44	Chicks strong; very active.
0.03 per cent. irradiated, heated, purified cholesterol	30	195	144	Good calcification	47	Chicks strong; very active.
0.06 per cent. irradiated, heated, purified cholesterol	60	169	121	Good calcification	45.5	Chicks strong; very active.
0.1 per cent. irradiated, purified cholesterol	1	133	86	Rickets	28.6	All symptoms of leg weakness; tendency to squat at 3 weeks.
0.01 per cent. irradiated filtrate residue from heated cholesterol	>10	110	63	Rickets	29.6	All symptoms of leg weakness; tendency to squat at 3 weeks.
0.01 per cent. irradiated cholesterol W	10	174	129	Good calcification	44.8	Chicks strong; very active.
0.03 per cent. irradiated cholesterol W	30	164	117	Good calcification	43	Chicks strong; very active.

The purified cholesterol was prepared through the dibromide. Irradiated, this unheated product produced a 2+ cure when fed to rats in 10-mg daily doses for 10 days. The Steenbock rat unit is therefore 100 mg. The heated cholesterol was prepared by placing 3 gm of the purified cholesterol in a 250-cc flask with two capillary openings and heating this in an oil bath to 185°–195° C. for one hour. The solidified mass was dissolved in boiling alcohol, and the crystals which separated at room temperature were filtered off, dried and irradiated. A daily dose of 0.1 mg produced a 2+ cure in rats. The semi-crystalline residue left after evaporation of the filtrate was also irradiated. Cholesterol W was a fairly pure product obtained from The Wilson Laboratories.

The results show unmistakably the superior effectiveness of cholesterol W and the heated purified cholesterol over viosterol or the purified, unheated cholesterol in preventing leg weakness. Ten rat units of either preparation per 100 gm of diet were equivalent to 0.25 per cent. or 10 rat units of cod liver oil. The provitamin D of heated cholesterol evidently separates readily in the crystallization from alcohol, since the filtrate residue has no potency when given in comparable doses to rats or chicks. The chicks receiving 100 rat units of viosterol per 100 gm of diet were in no better condition than those receiving the basal ration only.

This is a preliminary report. Efforts to concentrate the provitamin-D factor of heated cholesterol are under way.

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THE BLUE MUD-DAUBER AS A PREDATOR OF THE BLACK WIDOW SPIDER

DURING the past few months, a study of the black widow spider, *Latrodectus mactans* Fabr., was made to find a method of securing a large quantity of venom for experimental work. It was finally decided to breed black widows in large numbers. The question of food for the breeding stock and for growing young spiders became a problem. In the building where the cages were kept, many mud-dauber nests were observed, which suggested feeding spiders on the young mud-daubers found in them. This type of food was satisfactory—both young and adult spiders ate the larvae of the mud-daubers.

When a survey of the garage and other outbuildings on the premises was made, many mud-dauber nests were located. On examining a few nests, an interesting fact was discovered. The contents of the nests consisted entirely of numerous spiders stored up as food for the growing larvae. In checking the contents of various nests, it was found that many of the spiders were small immature black widows. In some nests the contents were all black widows, in others a mixture of various species of spiders, which included a few *Latrodectus mactans,* and in others none of this species was found (see Table I).

TABLE I

Nest No.	Black widows	All others
1	43	30
2	19	3
3	0	41*
4	19	17
5	16	13
6	0	52*
7	1	7
8	24	3
9	0	33*
10	54	10
11	10	8
12	5	12
13	3	28
Totals	**194**	**257**

* These were evidently nests of the large yellow-marked mud-dauber, whereas the others were undoubtedly the blue mud-dauber nests (see below).

The differences (Table I) noted in the counts of nests Nos. 3, 6 and 9 led to the belief that these were built by a different species. It was therefore thought advisable to make a study of the mud-daubers during construction of the nest. This showed that three separate types exist in this locality: Blue mud-dauber, *Chalybion cyaneum* (Klug); large yellow-marked mud-dauber, *Sceliphron caementarium* (Drury); small yellow-marked mud-dauber, *Trypoxylon texense* (Saussure).

After identifying the above three species of mud-daubers, a close watch was kept on each type during the construction of its nests. When completed, the mud-dauber was captured, the nest opened and a count of the contents made. The results are shown in Table II.

TABLE II

	Nest No.	Black widows	All others
Large yellow-marked mud-dauber	14	0	11
	15	0	10
	16	0	19
	17	0	9
	23	0	42
	24	0	56
	Totals	**0**	**147**
Blue mud-dauber	18	27	0
	19	14	37
	20	3	16
	21	35	56
	22	12	33
	Totals	**91**	**142**

The count as shown in the above table indicates that the large yellow-marked mud-dauber rejects the black widow, whereas the blue mud-dauber uses it as food for its young. Taking the total of 15 nests of the blue mud-dauber (Tables I and II) it was found that 285 black widow spiders had been stored in these nests, an average of 19 per nest.

This proves conclusively that the blue mud-dauber is an important predator of the black widow. The protection of the blue mud-dauber in those parts of the country where it exists and where the black widow is prevalent would tend to inhibit the propagation of this poisonous spider.

The writers are indebted to Dr. Karl V. Krombein, Department of Entomology, Cornell University, for confirming the identification of the species of mud-daubers.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

GLASS ELECTRODES

THE glass electrode possesses a number of advantages over other types of electrodes for determining hydrogen-ion concentrations. The chief objection to the thin membrane type of glass electrode is its fragility, which militates against its wide-spread use. Moreover, the potentials obtained with such electrodes vary, depending upon the depth of immersion. The thick membrane glass electrode is characterized by its high mechanical strength, making it applicable in many situations where the thin type could not be used satisfactorily. Since an increase in the thickness of the membrane entails a corresponding increase in its electrical resistance, the use of an amplifying system in conjunction with thick glass electrodes is essential. With the aid of certain inexpensive and highly stable single tube amplifiers now available, readings reproducible to a fraction of a millivolt can be obtained in a few seconds.

It should be noted, however, that the electrical resistance of the common forms of thick glass electrodes is sufficiently high to cause serious errors due to leakage over the surface of the glass shank. Furthermore, the potentials vary according to the depth

of immersion, similar to those obtained with thin membrane electrodes. To eliminate the first of these sources of error, it is essential to make the pathway of leakage as long as possible. If this is attempted by increasing the length of the glass shank, the result is an unwieldy piece of apparatus. A more satisfactory procedure consists in using two glass shanks, one placed within the other, and carefully sealed together at the bulb end of the electrode so that they contact each other only at this point, as shown in Fig. 1. The

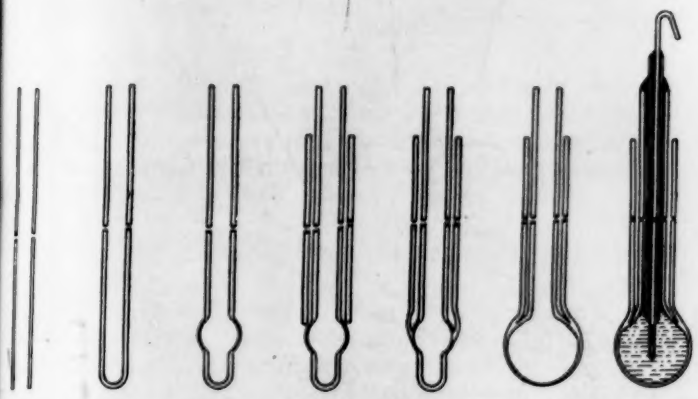

FIG. 1. Steps in the construction of the double-shank electrode.

pathway of leakage of an electrode with two shanks 5½ inches and 6½ inches long, respectively, is sixteen to seventeen inches in length, so that errors due to this source may be neglected. Moreover, since the inner shank of this electrode is completely insulated from the fluid which is being tested, the errors resulting from the effect of variation in the depth of immersion of the outer shank in the fluid are eliminated. It is essential of course to completely immerse the bulb.

An electrode of chemically pure silver wire is used as a reference electrode, and this is sealed inside a small glass tube completely filled with a sealing compound impervious to HCl, having one quarter inch of the wire protruding. After a silver chloride has been deposited upon the wire the latter is slipped inside the glass electrode until the treated tip is completely immersed in the N/10 HCl solution with which the bulb has previously been filled. The bulb is then sealed to prevent leakage of HCl by flowing hot sealing wax into the space between the silver electrode and glass shank.

A number of procedures can be used for assembling this form of glass electrode, one of which is illustrated in Fig. 1. Dry, chemically and physically clean Corning 015 glass only is used, and this is worked at the tip of a small oxy-gas flame, carefully avoiding the use of a carbon flame. Annealing of the glass junction must be thorough, and should be done only with a blue flame. It is essential to blow the bulb so as to form a thin, flexible junction between the two glass shanks, otherwise strains may be set up which eventually result in cracking. The bulb can be varied from 10 to 20 mm in diameter and from 0.05 mm to 0.5 mm in thickness without affecting the accuracy of the electrode. Repeated heating of the glass has no apparent deleterious effect upon its characteristics, provided it is worked at a sufficiently high temperature.

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A METHOD OF NUMBERING LABORATORY RATS

ALL those who have worked with a large number of rats and mice have experienced much difficulty in not being able to number the animals in a satisfactory manner. The method which I here suggest has been found easy and completely reliable. The plan of Dr. Strong, who uses the notches and holes in the ear, was incorporated in this scheme but was used in a different manner.

The toes of the hind feet are taken as units and the toes of the forefeet as 10's. The units begin on the small toe of the left hind foot, the animal being

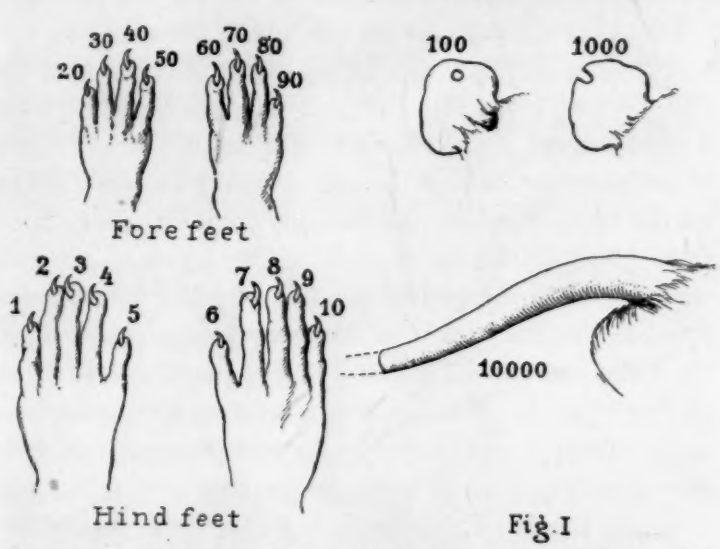

Fig. I

The numbering of the toes, the holes and notches in the ears and the clipping of the tail.

on its feet (see Fig. 1). No. 1 is the first toe, No. 2 the second toe and so on across to the other foot. From No. 5, the great toe on the left hind foot, the numbering goes directly across to No. 6, the great toe on the right hind foot. The last toe is No. 10. The first toe on the left forefoot is No. 20, and the last toe on the right forefoot is No. 90. To number the animal 13, the third toe, No. 3, on the left hind foot, and the last toe, No. 10, on the right hind foot, are clipped with a pair of scissors. No. 18 would be toe No. 8, right hind foot, and toe No. 10, right hind foot.

The hind toes permit the numbering up to 19, above that figure a combination is made of the 10's on the

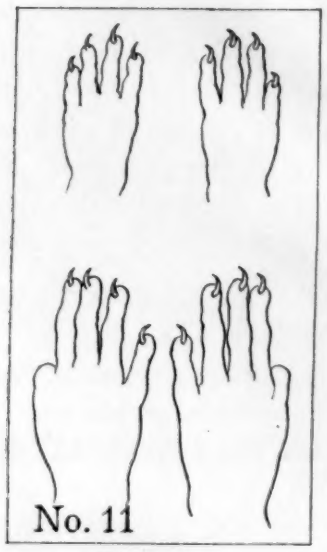

Fig. II
An animal's foot No. 11.

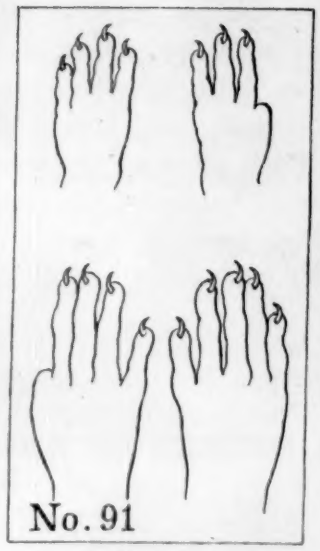

Fig. III
An animal's foot No. 91.

front toes and the units on the hind toes. For instance, No. 20 would be made by clipping the first toe on the left forefoot; No. 21 by clipping the first toe on the left forefoot and the first toe on the left hind foot. No. 56 would be made by clipping the fourth toe on the left forefoot and the great toe on the right hind foot. No. 91 (Fig. 3) would be the last toe on the right forefoot and the first toe on the left hind foot.

By using all the toes we can bring the numbers up to 99. No. 100 is made by punching a small hole in the ear with a small metal punch. One punched hole designates rat No. 100. No. 171 would be obtained by making one hole in the ear, clipping the second toe on the right forefoot and the first toe on the left hind foot. No. 271 is designated by two holes in the ear with the same clipped toes. Rat No. 571 would have five holes in the ears with the same toes. The ears, if the holes are placed carefully, will permit from four to five in each. Four will prove to be quite satisfactory. The punched holes heal quite promptly as definite perforations or holes unless they are made too close to the head; in that case they will be apt to close almost completely. No. 1,000 is signified by notches made in the margin of the ear. These can be done with the same punch. Care must be taken to punch the margin deeply enough so that healing will give clear-cut notches. No. 1,171 would be represented by 1 notch, 1 hole, and by clippings on the second toe of the right forefoot and the first toe of the left hind foot. No. 5,283 would be shown by 5 notches, 2 holes, and by a clipping of the third toe on the right forefoot and the third toe on the left hind foot, respectively. The notches, the holes and the toes carry the numbers up to 10,000.

No. 10,000 is made by clipping about half an inch off the tail. After this clipping, the same method with the toes and ears is used again. No. 11,235 (see Fig. 4) is represented by a clipped tail, 2 holes and 1

Fig. IV
Toes, ears and tail of animal No. 11,235.

notch in the ear and the clipping of the second toe of the left forefoot and the fifth toe of the left hind foot.

This system has been used for a colony of 13,000 animals and found quite satisfactory. It was possible to recognize the number of any animal which had escaped from the cage and by reference to the records to put it back into its proper place.

Rabbits and guinea pigs may be numbered in the same way.

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